BAY AREA REGIONAL RAIL PLAN

Technical Memorandum 4d

Regional Rail Signal and Communications System Engineering and Costs

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EarthTech
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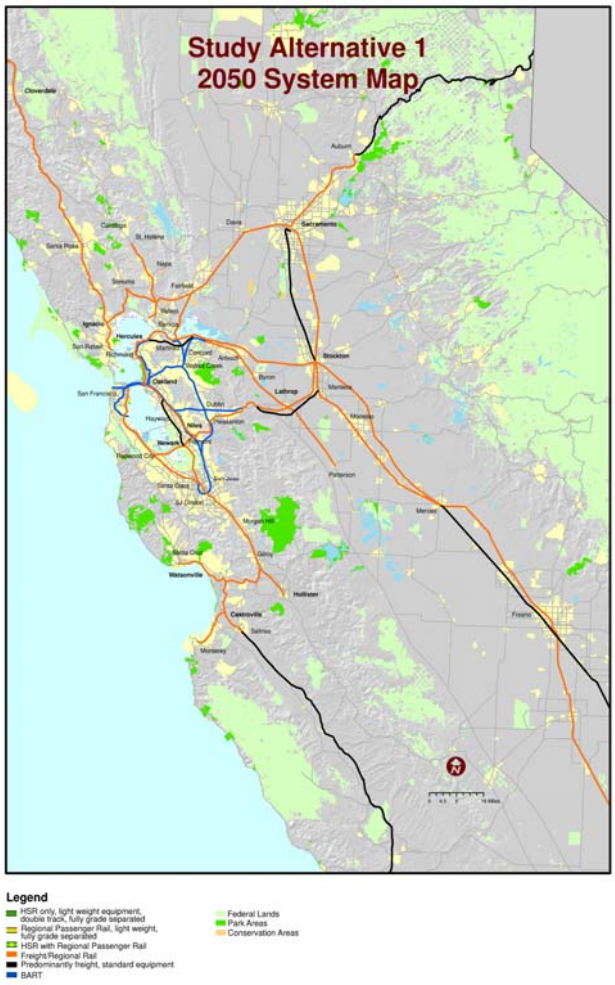
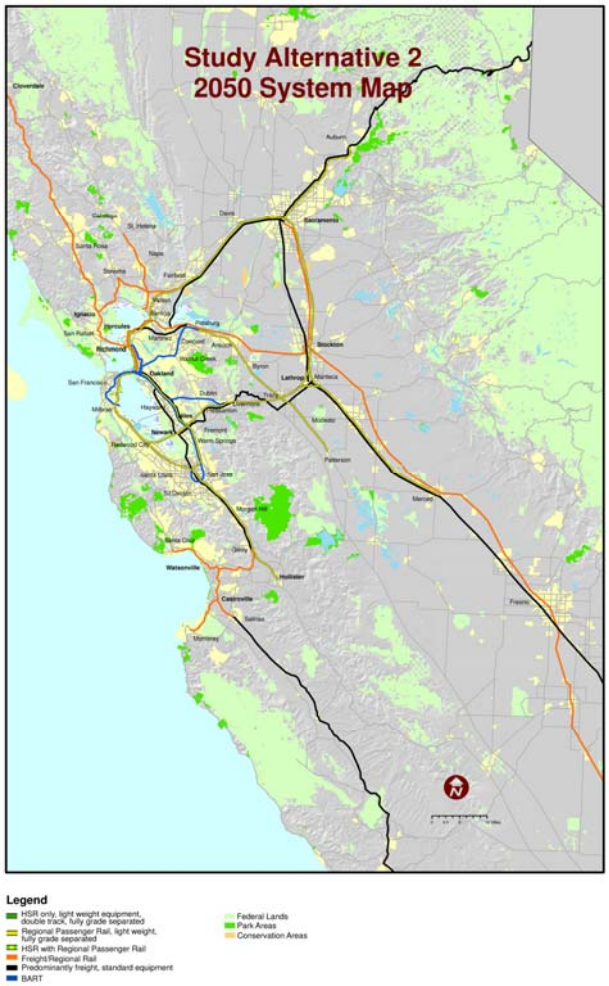
Korve Engineering

Scope of Work

For each Study Alternative, CONSULTANT shall perform signal and communication systems engineering and cost estimation, to an appropriate level of confidence. The level of detail for this task to be commensurate with the budget and need to evaluate the merits of each alternative.





Executive Summary

Signal system improvements are addressed in four different stages of the growth of the Regional Rail System as illustrated in the Study Alternative 1 and 2 maps; see attached. First the initial signal systems must be upgraded for minimal passenger operations to begin commuter type operations over existing freight systems. Second, tracks are added for higher volume of services as the system moves to separate the freight and passenger tracks, with conventional signaling systems installed on added tracks. Third, the separation of tracks becomes complete as passenger services are provided with non-compliant vehicles capable of operating beyond the conventional signal

system capabilities. And fourth, the introduction of high speed rail services on the fully separated passenger system.

For the study area and proposed alternatives, signaling requirements fall into three categories:

1. Upgrade to CTC and installation of CTC on new tracks
2. Electrification for operation up to 150 MPH
3. Upgrade to High Speed Operation, mainline tracks only to 250 MPH

These options are provided as upgrades to existing systems, and typically can be done independently. As the freight and passenger rails become isolated, operating switches between them will be deactivated to allow increased speed limits for higher speeds.

A primary signaling concern for each of these is coordination with a presumably new and centralized regional passenger rail control facility, since the potential exists for different types of signal systems from different manufacturers to need to interface to the same control center. The differences in these costs are estimated in this report.

Potential signal system requirements are discussed below for each rail segment, based on the alternatives being considered. Specific issues are addressed on a segment-by-segment basis. For immediate enhancement in dark territory operations, significant improvement in capacity can be realized for relatively low cost using a Radio-Controlled Switch System, for example, using the Fas-Pas System by Global Rail Systems (Marlin, Texas). This type of system might provide a reasonable alternative to a CTC system in areas where high volume traffic may not be immediately realized, such as the Smart Corridor. The estimates provided in this report begin with CTC for all commuter rail operation segments, since other options have not been seriously considered in the past.

Communications requirements for this study are different than signaling since the requirements for communications systems will vary depending on local needs, but will also require coordination to a regional rail central control facility. The communications costs for each segment are based on primarily wayside improvements for connection to an existing CTC system that is easily expandable. Thus, the communications costs are considered the minimum possible for each segment. It is also assumed that Union Pacific and Burlington Northern Railroads will NOT accept CTC responsibility for any commuter line that exceeds 79 miles per hour, and that this service will be provided by a single regional rail authority CTC center until other alternatives are suggested.

For the Signaling and Communications (S&C) cost estimates provided, any vehicle S&C equipment costs are not included. The only exclusion to this premise is the High Speed Rail option that includes the vehicle costs as part of the integral system, and that installation of this system is complete on installation, and not a system that can be progressively or incrementally improved by adding layers to the system.

A brief signaling system overview is provided to help the reader get a basic understanding of the primary features or differences between the different signal systems. The costs for these systems are based on recent history of systems installed on freight railroad operations, Amtrak, and/or the French TGV High Speed system (TGV – ‘train à grande vitesse’, French for High Speed Train).

Diversity in signal systems are typically dictated by the train propulsion systems, whether Deisel locomotive or AC or DC propulsion, or requirements for acceleration and braking, as well as operation, such as train minimum headways. Systems range from distributed wayside components

to centralized equiment houses. Equipment and systems compliance or non-compliance to FRA, CPUC or other requirements also impact the signal system architecture and costs. The cost estimates are generalized for purposes of this report since many of the system variables that can impact the cost have yet to be defined. Even those systems that are defined now may need to re-define their structure within the next 5 to 20 years as the operational requirements change. The cost estimates provided are effective for cost comparison purposes, and for making high level system impact judgements on the system costs only.

Caltrain

Caltrain's existing plans include an interim and long-term approach to signaling and preparing for impacts on their signal system.

The interim approach includes a plan for underlying (existing) track circuits based signal system that will accommodate:

- Future electrification (DC or AC propulsion compatible)
- 5-minute headways to enhance operations
- Make grade crossings compatible with electrification, and
- GPS tracking of trains (enhanced communications capabilities)

The Caltrain long-term plan includes investigation of Positive Train Control (PTC) as a means to running electro-motive propulsion units (EMU's). PTC could offer benefits for both safety and performance.

For increased communications needs, Caltrain intends to install a fiber-optic communications backbone to support both non-vital signal and administrative communications needs as well as potential vital needs of a PTC signal system. Caltrain's plans include the ability to link to adjacent properties and outside agencies. This communications backbone will support a link to a Regional Rail Central Control Center if established for the region.

Corridors

Smart Corridor

This segment includes Cloverdale to Ignacio and Ignacio to Larkspur. For all study alternatives, this segment remains freight and regional commuter rail operation. Basic signal system improvements to meet the goals of the 2050 system alternatives include potential dark territory Radio-Controlled Remote Switch Control, Absolute Block System or Centralized Traffic Control. Typical costs for these upgrades are provided below.

Ignacio to Fairfield/Suisun

This segment includes Ignacio to Napa River and Napa River to Fairfield/Suisun. For all study alternatives, this segment remains freight and regional commuter rail operation. Basic signal system improvements to meet the goals of the 2050 system alternatives include potential dark territory Radio-Controlled Remote Switch Control, Absolute Block System or Centralized Traffic Control. Typical costs for these upgrades are provided below.

St. Helena to Vallejo

This segment includes St. Helen to Krug, Krug to Napa, and Napa to Vallejo. For all study alternatives, this segment remains freight and regional commuter rail operation. Basic signal system improvements to meet the goals of the 2050 system alternatives include potential dark territory

Radio-Controlled Remote Switch Control, Absolute Block System or Centralized Traffic Control. Typical costs for these upgrades are provided below.

Sacramento to Oakland

This segment includes Sacramento to Martinez and Martinez to Oakland, currently the Amtrak Capitol Corridor service segment. For study alternatives 1 and 2, this segment separates the freight and regional commuter rail operations. Basic signal system improvements to meet the goals of these system alternatives include possible electrification and upgrade of the commuter tracks from the existing Centralized Traffic Control to Amtrak Acela-like service to 150 MPH.

This segment migrates from 2-track to 4-tracks, one pair of tracks for freight operation exclusively, and the other set exclusively for commuter train service. The existing CTC signal system could remain for the freight service, and would serve for increased freight traffic from the Port of Oakland as passenger services are moved to the new track pair. CTC control and supervision would remain with Union Pacific Railroad. Some signaling costs would be involved during the phased transition of service during the installation and commissioning of the new track pair, typically for relocation and re-testing of existing wayside equipment. This support costs for signaling typically average in the order of $15,000.00 per track mile for a well-phased plan, but costs could escalate to double or triple this amount if multiple phases are required concurrently.

The new commuter track operation could be a phased operation over a number of years, beginning with diesel power over a coded track CTC system very similar to the existing system today, with increased commuter traffic realized by the isolation from freight traffic. A regional rail CTC control center would be required for this exclusive commuter rail operation as it separates from the freight tracks. Costs for the wayside signaling for the new tracks would average $150,000.00 per mile for speeds to 70 MPH. The control center costs would be additional, and would depend on the facilities selected; the CTC and communications costs for the control center typically cost $4-$6 million depending on the level of control and supervision requested. It would be beneficial for this system to have easy expansion capability to provide for the likely tripling of control and supervision points during electrification, as well as providing for SCADA or SCADA-type services needed for the electrification system.

This system can be expanded as the system transitions to electrified propulsion, and then finally migrated to a high-speed Acela-like system. Transition to an electrified system typically triples the wayside components needed for signaling as track circuits shrink from an average 12,000-foot long circuits to an average 4,000-foot circuit for conventional signaling, and impedance bonds are added. Options to this include an Incremental Train Control System, or ITCS-type or Communications Bases Train Control (CBTC) system, either with the potential for Positive Train Control (PTC - see Train Control Systems below). For a conventional coded-track system with an electrified interface, the transition to 150 MPH system is typically a software change for each wayside unit that includes a full system test that can take weeks to complete. Costs are usually labor costs only, ranging from $20,000.00 per mile to much higher depending on test cycles required, and delays for normal operations.

Auburn to Sacramento

For study alternatives 2, this segment separates the freight and regional commuter rail operations. This segment is typically included as part of the Capitol Corridor (see Sacramento to Oakland above) and should be considered as an extension of this corridor, with fully compatible signaling since the trains typically progress to and from each other. Changes in the type of service between these two segments would typically require a change of train at Sacramento, for example if diesel propulsion service for this corridor is maintained while the Sacramento to Oakland segment is electrified.

Stockton to Oakland

This segment includes Stockton to Port Chicago, Port Chicago to Stege, Port Chicago to Martinez, and Martinez to Oakland, currently known as part of the Amtrak San Joaquins corridor. For all study alternatives, this segment remains freight and regional commuter rail operation. Basic signal system improvements to meet the goals of the 2050 system alternatives include upgrading the current mix of ABS and CTC to a Centralized Traffic Control. Typical costs for these upgrades are provided below.

Lathrop to Martinez

This segment includes Lathrop to Tracy, Tracy to Antioch, Antioch to Port Chicago, and Port Chicago to Martinez. Depending on the study alternatives, this segment could include eBART and/or freight mixed with commuter rail operations. Basic signal system improvements to meet the goals of the 2050 system alternatives include upgrading the current mix of dark, ABS, and limited CTC to Absolute Block System or Centralized Traffic Control. Typical costs for these upgrades are provided below.

The eBART line would be signaled similarly, with CTC, though the projected project headways would require comprehensive signaling for CTC, or it would be a good candidate for CBTC or ITCS. Due to ridership projections, some form of PTS would be necessary as well. The eBART concept is relatively new, has no prior implementation, and could range in cost from conventional CTC costs ($150,000.00 per mile) to much higher costs.

Both eBART and commuter lines in this segment would need communications to a control center for train control as well as other services. Since the eBART has a requirement for single pass operation, even connecting thru Pittsburg station then into the main BART system, this communications would require tie-in with BART's fare collection system as well. If both systems fall under the same regional rail authority, then a common control center could reduce costs, but a tie-in with the BART system is required for coordination, meets and scheduling. BART's role in the regional rail system would depend on close cooperation for an efficient operation in this segment. Optionally, having the fare collection system for eBART linked with BART's system would still leave a gap in meets at Pittsburg unless BART took the lead in control, and the regional rails role was in supervision and oversight, including external interfaces, such as bus meets, at most.

Sacramento to Merced

This segment includes three alternative routes from Sacramento to Stockton, and two routes from Stockton to Merced. The study alternatives for this segment include many options including different combinations of high-speed rail, commuter and high-speed commuter rail, and freight options. The separation of freight traffic from the same tracks as passenger traffic provides the highest operating levels.

Basic signal system improvements to meet the goals of the 2050 system alternatives include full Centralized Traffic Control for all freight operations, electrification and high speed commuter (150 MPH) and high speed thru train operations (250 MPH). Typical signaling costs for these upgrades are provided below.

The freight line should maintain their own CTC communications that currently exists on these tracks. New track will provide for high speed commuter and high speed thru traffic, using some form of CTC with a regional rail authority. Burlington Northern has recently received FRA approval for installation of a Positive Train Control System, BN's Electronic Train Management System (ETMS), that is likely to be installed on BN's trackage in this corridor.

Tracy to Patterson

For all study alternatives, this segment remains freight with regional commuter rail operation. Basic signal system improvements to meet the goals of the 2050 system alternatives include

potential dark territory Radio-Controlled Remote Switch Control, Absolute Block System or Centralized Traffic Control. Typical costs for these upgrades are provided below.

Niles Junction to Stockton

This segment includes Niles Junction to Stockton (the existing ACE corridor), and Niles Junction to Tracy. The study alternatives for this segment include many options including different combinations of high-speed rail, commuter and high-speed commuter rail, and freight options. The separation of freight traffic from the same tracks as passenger traffic provides the highest operating levels.

Basic signal system improvements to meet the goals of the 2050 system alternatives include full Centralized Traffic Control for all freight operations, electrification and high speed commuter (150 MPH) and high speed thru train operations (250 MPH). Typical signaling costs for these upgrades are provided below.

The freight line should maintain their own CTC communications that currently exists on these tracks. New track will provide for high speed commuter and high speed thru traffic, using some form of CTC with a regional rail authority.

Oakland to San Jose

This segment includes a multitude of routes from Oakland to San Jose, many along existing rail corridors with existing signal systems ranging from full three-track CTC to abandoned. The study alternatives for this segment include many options including different combinations of high-speed rail, commuter and high-speed commuter rail, and freight options. The separation of freight traffic from the same tracks as passenger traffic provides the highest operating levels.

Basic signal system improvements to meet the goals of the 2050 system alternatives include full Centralized Traffic Control for all freight operations, electrification and high speed commuter (150 MPH) and high speed thru train operations (250 MPH). Typical signaling costs for these upgrades are provided below.

The freight line should maintain their own CTC communications that currently exists on these tracks. New track will provide for high speed commuter and high speed thru traffic, using some form of CTC with a regional rail authority.

San Francisco to San Jose

This segment of PCJPB right-of-way is mostly 4-track already allowing for full CTC on two tracks for commuter traffic, and two tracks of ABS for the limited freight operations. The study alternatives for this segment include many options including different combinations of high-speed rail, commuter and high-speed commuter rail, and freight options. The separation of freight traffic from the same tracks as passenger traffic provides the highest operating levels. Current freight operations on this line are time-separated from the passenger services, running only late in the day when passenger service in not occurring. This type of separation is adequate as long as it is viable, which in this case works well.

Basic signal system improvements to meet the goals of the 2050 system alternatives include full Centralized Traffic Control for all freight operations, electrification and high speed commuter (150 MPH) and high speed thru train operations (250 MPH). Typical signaling costs for these upgrades are provided below.

The freight line should maintain their own CTC communications that currently exists on these tracks. New track will provide for high speed commuter and high speed thru traffic, using some form of CTC with a regional rail authority

Redwood Junction to Newark

For all study alternatives, this segment remains freight and regional commuter rail operation. Basic signal system improvements to meet the goals of the 2050 system alternatives include

upgrading the current mix of ABS and CTC to a Centralized Traffic Control. Typical costs for these upgrades are provided below.

San Jose to Salinas

This segment includes San Jose to Gilroy and Gilroy to Salinas. The study alternatives for this segment include many options including different combinations of high-speed rail, commuter and high-speed commuter rail, and freight options. The separation of freight traffic from the same tracks as passenger traffic provides the highest operating levels.

Basic signal system improvements to meet the goals of the 2050 system alternatives include full Centralized Traffic Control for all freight operations, electrification and high speed commuter (150 MPH) and high speed thru train operations (250 MPH). Typical signaling costs for these upgrades are provided below.

The freight line should maintain their own CTC communications that currently exists on these tracks. New track will provide for high speed commuter and high speed thru traffic, using some form of CTC with a regional rail authority.

Santa Cruz to Watsonville Junction
Castroville to Monterey
Gilroy to Hollister

These three segments provide rail services between Santa Cruz and Monterey and Salinas. For all study alternatives, this segment remains freight and regional commuter rail operation. Basic signal system improvements to meet the goals of the 2050 system alternatives include potential dark territory Radio-Controlled Remote Switch Control, Absolute Block System or Centralized Traffic Control. Typical costs for these upgrades are provided below.

Train Control Systems

Dark Territory

Train traffic is governed by manual orders for movement. Manual written orders provide train authority to proceed between designated control points while other traffic within the same area are prohibited from operation. It is required that authority to grant permission over the track is limited to a single control entity, typically the owner of those tracks. Contrary to popular Hollywood stereotyping, dark territory is not totally dark. As the name implies, the track typically has no wayside signals, or signals a control points only; radio contact between the control centers and trains on the track provide almost comprehensive coverage in most cases.

Relative Cost: None
Baseline for adding signaling

Dark Territory w/ Fas-Pas Radio-Controlled Switch Control

Train traffic governed by manual orders for movement, with train capability to remotely control switches using their standard radio keypad – Capacity improvement over dark territory with manual switches of about 35% can be achieved by allowing trains to route their movement without stopping to operate and restore either hand-operated of powered switches. These systems are popular on Kansas City Southern Railroad, while gaining popularity on Class 1 operations over dark territory.

Relative Cost: $25,000.00 per mile

Automatic Block System (ABS)

Automatic traffic routing based on first-come first-serve; wayside signals control movement based on occupancy in advance of train; routes manually selected at control points. Wayside signals provide engineers an aspect to proceed within the next block of operation, ranging from 8,000' to 24,000', with passing sidings every 8-12 miles.

Relative Cost: $85,000.00 per mile

Centralized Traffic Control (CTC)

Requires a dispatcher at a centralized control location. For purposes of this estimate and report, a single system control center is estimated for all Northern California regional Rail (NCRR) activity. Traffic is controlled by wayside signals, with remote control of power switches at control points by dispatch personnel at a centralized control location; system-wide monitoring of traffic at a centralized location; routes set by dispatchers at central control. Typical operation uses wayside signals with a train control system that can take different forms.

Relative Cost: $150,000.00 per mile
Double Track Cost: $285,000.00 per mile

Amtrak Acela High Speed (150 MPH)

Same as CTC, with dual-frequency cab signals providing on-board continuous speed display and over-run protection. Cab signals are required on any FRA compliant system with speeds exceeding 79 MPH; cab signals provide continuous display of the signal aspect on-board the vehicle for the train operator and in many cases include enforcement capabilities if the operator attempts to exceed his authority. This type of system is typically provided with wayside system compatible with electrified rails, shorter blocks with closer headways. Typically separate passenger traffic from freight, either physically by different tracks, or by time. For example, running freight traffic at night during lowest passenger utilization periods.

Relative Cost: $185,000.00 per track mile
Plus $60,000.00 per lead propulsion unit

Automatic Train Operation (ATO)

Automatic Train Operation can be found on high density passenger lines. As the name implies, the operation is fully automatic in operation, or very nearly fully automatic. With ATO, vehicle operation and movement is automatic, and an operator is not necessary. Many systems with ATO, such as BART, have an operator on board to facilitate operation, and provide immediate override operation under system failures.

Relative Cost: $325,000.00 per mile
Plus $85,000.00 per lead propulsion unit

Positive Train Control (PTC)

Positive Train Control provides a signaling system that assures proper vehicle separation at all times. In concept, though not fully implemented at this time, PTC provides an operator with aspect or speed control information at all times. At the same time, vehicle operation by the operator is inhibited if the operator exceeds the authorized speed, forcing the vehicle to stop. Some transit operations, such as Metro St. Louis use a form of PTC.

Relative Cost: $250,000.00 per mile
Plus $55,000.00 per lead propulsion unit

Incremental Train Control System (ITCS)

An ITCS system takes the basis of the existing signal system, typically a CTC system, and incrementally adds layers to the wayside equipment as features, improvements, and control enhancements are added. These systems, implemented in Michigan and Illinois on certain Amtrak segments have improved service operations from 70 MPH to 90 MPH with closer headways possible. Layers typically include an on-board cab component, a vital wayside controller, and a wireless communications network. Configurations and cost vary as features are added, including use of GPS (Global Positioning System), added positive train control features, etc.

Communications Based Train Control (CBTC)

Communications Based Train Control is a train control system that provides train control using a communications-based system for both vehicle location detection and for providing train control information to the vehicle for either an operator or ATC system. CBTC is typically considered an automated control system using data communications between various control entities that make up the system.

Relative Cost: $88,000.00 per mile for short systems
Longer systems average higher costs
Plus $100,000.00 per lead propulsion unit

High-Speed Train Control (over 150 MPH)

The TGV uses a fixed block system with cab signals, similar to the Acela High Speed system but with some key differences. The blocks are typically shorter but the number of blocks for train control is increased with respect to the allowable speed. For example, the TVM 300 operation at 300 km/hr requires 5 blocks braking distance; the TVM 430 operation at the maximum 360 km/hr speed requires 6 blocks for braking. In each case the train headways are adjusted for multiple blocks depending on local speed and operation. There is currently no signal system in the US that provides train speeds above 150 MPH.

Relative Cost: $1,000,000.00 per mile
Plus $75,000.00 per lead propulsion unit

Discussion

The signaling of a high speed line requires a different approach from conventional railways. The speed of the TGV, for example, is high enough that the driver cannot reliably read wayside signals. Wayside cab signals applied to the rails provide continuous onboard display of permissible train speed for the driver. Cab signaling, though common worldwide, has limited application in the US. The most significant of these is Amtrak's application in the Northeast Corridor for Acela service from Boston to Washington DC. The signal system for this service evolved from a Centralized Traffic Control (CTC) block system with wayside signals to cab signaled, to electrified rail, to high speed operation (150 MPH). To date, speeds higher than 150 MPH have not been realized by a signal system within the US. In Europe, mixture of InterCity Express (ICE) trains having a maximum signaled speed of 150 MPH with high speed operations similar to the TGV (up to 250 MPH) is still in initial stages of development.

While upgrading Amtrak's NE Corridor for higher speed operation is limited by more than the signal system, namely the lack of real estate for appropriate track development, a High Speed system from Southern to Northern California provides an ideal setting for the track development. From a signaling standpoint, however, the technology does not yet fully exist to implement a signal system if the trackwork was ready today. Further, though the system could be developed and implemented during the next 20 to 30 years, the potential for operating on the same track as local commuter systems will require careful coordination between the different types of service.

Caltrain's specifications for recent signal system upgrades in the peninsula corridor bear a striking resemblance to those of Amtrak's NE Corridor service prior to Acela. They specify a coded DC Track system that is capable of easy upgrade via additional hardware and software to add cab signals, as well as capability for operation as the track may be electrified. The US signal supply industry provides this system using Electro Code 4 or equivalent coded track systems with capability for software upgrading of operation, as well as additional electrified track interface for operation on electrified rail. The electrified track interface available today also provide cab signal capabilities for single 100-hertz speed codes or dual frequency 100- and 250-Hertz coded cab capabilities similar to that provided in Amtrak's NE Corridor. To date, however, these systems have no proven capabilities for operation beyond 150 MPH.

Any railroad line with even remote plans for potential high speed operation must consider the signal systems capabilities for high speed to best provide a system that can be adapted to this service to avoid the potential of having to obsolete the existing signal system to achieve high speed operation (over 150 MPH). With any type of rail system, the number of highway grade crossings must be minimized or eliminated, and these costs can become significant in areas of higher highway density.

Communications options assume that the Northern California Regional Rail (NCRR) Authority will be established to control and monitor the passenger operations throughout this study area. A central control facility will provide control and monitoring of track over NCRR operations, and that consolidation of the CTC interfaces at the office end will be realized. No costs are estimated for the office equipment for this facility, as these will depend on the final location and facilities for this function.

Cost Estimates

The attached matrix provides relative cost estimates for each alternative. No cost estimations are made for BART or freight options. Amounts shown are in millions of dollars. Estimates are based on simplest option from the current condition to the stated alternative; in many cases, additional costs can be incurred by added phasing or intermediate stages.

Communications estimates include the basic installation requirements for CTC including a SCADA or SCADA-type system with potential for increased communications capabilities as required.

Corridor		Miles	Current Condition 2006				Study Alternatives							
							Alternative 1		Alternative 2		Alternative 4		Alternative 12	
			Tracks	Speed	Signals	Comm	Signals	Comm	Signals	Comm	Signals	Comm	Signals	Comm
Smart Corridor	Cloverdale to Ignacio	60	1	10 MPH	None	None	CTC	NCRR	CTC	NCRR	CTC	NCRR	CTC	NCRR
	Ignacio to Larkspur	9	1	10 MPH	None	None	CTC	NCRR	CTC	NCRR	CTC	NCRR	CTC	NCRR
Ignacio to Fairfield / Suisun	Ignacio to Napa River	23	1	10 MPH	None	None	CTC	NCRR	CTC	NCRR	CTC	NCRR	CTC	NCRR
	Napa River to Fairfield / Suisun City	16	1	25 MPH	None	None	CTC	NCRR	CTC	NCRR	CTC	NCRR	CTC	NCRR
Calistoga to Vallejo	Calistoga to Krug	7	0	0 MPH	None	None	CTC	NCRR	CTC	NCRR	CTC	NCRR	CTC	NCRR
	Krug to Napa	22	1	15 MPH	None	None	CTC	NCRR	CTC	NCRR	CTC	NCRR	CTC	NCRR
	Napa to Vallejo	13	1	10 MPH	None	None	CTC	NCRR	CTC	NCRR	CTC	NCRR	CTC	NCRR
Sacramento to Oakland	Sacramento to Martinez	56	2	79 MPH	CTC	UPRR	CTC	UPRR	150 MPH	NCRR	150 MPH	NCRR	CTC	UPRR
	Martinez to Oakland	30	2	79 MPH	CTC	UPRR	CTC	UPRR	150 MPH	NCRR	150 MPH	NCRR	CTC	UPRR
Auburn to Sacrmento		18	2	50 MPH	CTC	UPRR	CTC	UPRR	150 MPH	NCRR	150 MPH	NCRR	CTC	UPRR
Stockton to Oakland	Stockton to Port Chicago	43	1	79 MPH	A / C	BNSF	CTC	BNSF	CTC	BNSF	CTC	BNSF	CTC	BNSF
	Port Chicago to Stege	28	1	45 MPH	ABS	BNSF	CTC	BNSF	CTC	BNSF	CTC	BNSF	CTC	BNSF
	Port Chicago to Martinez	6	1	79 MPH	CTC	UPRR	CTC	UPRR	CTC	UPRR	CTC	UPRR	CTC	UPRR
	Martinez to Oakland	30	2	79 MPH	CTC	UPRR	CTC	UPRR	CTC	UPRR	CTC	UPRR	CTC	UPRR
Lathrop to Martinez	Lathrop to Tracy	10	1	25 MPH	TWC	UPRR	CTC	UPRR	150 MPH	NCRR	CTC	NCRR	HSR	NCRR
	Lathrop to Tracy	10							CTC	UPRR			CTC	UPRR
	Tracy to Antioch	30	1	25 MPH	None	None	eBART	BART	CTC	NCRR	CTC	NCRR	eBART	BART
	Antioch to Port Chicago	12	1	25 MPH	ABS	UPRR	eBART	BART	eBART	BART	eBART	BART	eBART	BART
	Antioch to Port Chicago	12							CTC	NCRR	CTC	NCRR		
	Port Chicago to Martinez	6	2	79 MPH	CTC	UPRR	BART	BART	CTC	NCRR	CTC	NCRR	CTC	NCRR
	Port Chicago to Martinez	6					CTC	NCRR	CTC	NCRR	CTC	NCRR		
Sacramento to Merced	Sacramento to Stockton - UP Sac	48	1	70 MPH	CTC	UPRR	CTC	UPRR	CTC	UPRR	CTC	UPRR	CTC	UPRR
	Sacramento to Stockton - UP Fresno	48	1+	79 MPH	CTC	UPRR	CTC	NCRR	CTC	UPRR	CTC	UPRR	CTC	UPRR
	Sacramento to Stockton - UP Fresno	48							150 MPH	NCRR			HSR	NCRR

Corridor			Current Condition 2006				Study Alternatives							
	Sacramento (Polk) to Stockton	42	1	25 MPH	None	None					HSR	NCRR	150 MPH	NCRR
	Stockton to Merced - UP Fresno	66	1	60 MPH	CTC	UPRR	CTC	NCRR	CTC	UPRR	CTC	NCRR	CTC	UPRR
	Stockton to Merced - UP Fresno	66							150 MPH	NCRR			HSR	NCRR
	Stockton to Merced - BNSF	66	1+	79 MPH	CTC	BNSF	CTC	NCRR	CTC	NCRR	CTC	NCRR	CTC	NCRR
	Stockton to Merced - BNSF	66									HSR	NCRR		
Tracy to Los Banos		57	1	25 MPH	TWC	UPRR	CTC	NCRR	CTC	NCRR			CTC	UPRR
Niles Juntion to Stockton	UP Oakland Subdivision (ACE)	63	1	79 MPH	CTC	UPRR	CTC	NCRR	150 MPH	NCRR	CTC	NCRR	CTC	UPRR
	UP Oakland Subdivision (ACE)	63							CTC	UPRR			HSR	NCRR
	Niles Junction to Tracy (Altamont Pass)	42	1	10 MPH	None	None	CTC	NCRR	CTC	NCRR				
Oakland to San Jose	UP Coast Subdivision	34	1+	70 MPH	A / C	UPRR	CTC	UPRR	CTC	UPRR	CTC	UPRR	CTC	UPRR
	UP Niles Subdivision	31	2	79 MPH	CTC	UPRR	CTC	NCRR	CTC	UPRR	CTC	NCRR	CTC	NCRR
	UP Niles Subdivision	15.5											CTC	NCRR
	UP Oakland Subdivision	20	1	60 MPH	CTC	UPRR	CTC	UPRR	150 MPH	NCRR			CTC	NCRR
	Warm Springs Sudivision	18	1	25 MPH	ABS	None	CTC	UPRR	150 MPH	NCRR			HSR	NCRR
	UP San Jose Branch	19	1	10 MPH	None	None	CTC	UPRR			CTC	NCRR		
San Francisco to San Jose	Caltrain Corridor	47	2+	70 MPH	CTC	PCJPB	CTC	NCRR	150 MPH	NCRR	HSR	NCRR	HSR	NCRR
Redwood Juction to Newark	Old SP Dumbarton	11	1	10 MPH	None	PCJPB	CTC	NCRR	150 MPH	NCRR	CTC	NCRR	HSR	NCRR
San Jose to Salinas	San Jose to Gilroy	30	1+	79 MPH	CTC	UPRR	CTC	NCRR	CTC	UPRR	CTC	NCRR	CTC	NCRR
	San Jose to Gilroy	30							150 MPH	NCRR	HSR	NCRR		
	Gilroy to Salinas	38	1+	60 MPH	CTC	UPRR	CTC	NCRR	150 MPH	NCRR	CTC	NCRR	CTC	NCRR
Iron Horse Trail	Old SP San Ramon Branch	30	None	None	None	None	BART	BART					BART	BART
Santa Cruz to Watsonville		21	1	10 MPH	None	None	CTC	NCRR	CTC	NCRR	CTC	NCRR	CTC	NCRR
Castroville to Monterey		13	1	0	None	None	CTC	NCRR	CTC	NCRR	CTC	NCRR	CTC	NCRR
Carnadero to Hollister		13	1	10 MPH	None	None	CTC	NCRR			CTC	NCRR	CTC	NCRR
Old Sacramento Northern	West Sacramento to Riverview	4	1	10 MPH	None	None								

Corridor			Current Condition 2006				Study Alternatives
	Riverview to Dozier	17	0	0	None	None	
	Dozier to Montezuma	26	1	10 MPH	None	None	
	Montezuma to Chipps	3	0	0	None	None	

CTC - Centralized Traffic Control
UPRR - Omaha, NE
BNSF - Ft. Worth, TX
ABS - Absolute Block System
A / C - Mix of ABS and CTC

BART - Bay Area Rapid Transit
NCRR - Northern California Regional Rail Authority

Corridor		Miles	Current Condition 2006				Study Alternatives							
							Alternative 1		Alternative 2		Alternative 4		Alternative 12	
			Tracks	Speed	Signals	Comm	Signals	Comm	Signals	Comm	Signals	Comm	Signals	Comm
Smart Corridor	Cloverdale to Ignacio	60	1	10 MPH	None	None	9.000	4.800	9.000	4.800	9.000	4.800	9.000	4.800
	Ignacio to Larkspur	9	1	10 MPH	None	None	1.350	0.720	1.350	0.720	1.350	0.720	1.350	0.720
Ignacio to Fairfield / Suisun	Ignacio to Napa River	23	1	10 MPH	None	None	3.450	1.840	3.450	1.840	3.450	1.840	3.450	1.840
	Napa River to Fairfield / Suisun City	16	1	25 MPH	None	None	2.400	1.280	2.400	1.280	2.400	1.280	2.400	1.280
Calistoga to Vallejo	Calistoga to Krug	7	0	0 MPH	None	None	1.050	0.560	1.050	0.560	1.050	0.560	1.050	0.560
	Krug to Napa	22	1	15 MPH	None	None	3.300	1.760	3.300	1.760	3.300	1.760	3.300	1.760
	Napa to Vallejo	13	1	10 MPH	None	None	1.950	1.040	1.950	1.040	1.950	1.040	1.950	1.040
Sacramento to Oakland	Sacramento to Martinez	56	2	79 MPH	CTC	UPRR	0.000	0.000	10.360	8.400	10.360	8.400	0.000	0.000
	Martinez to Oakland	30	2	79 MPH	CTC	UPRR	0.000	0.000	5.550	4.500	5.550	4.500	0.000	0.000
Auburn to Sacrmento		38	2	50 MPH	CTC	UPRR	0.000	0.000	7.030	5.700	7.030	5.700	0.000	0.000
Stockton to Oakland	Stockton to Port Chicago	43	1	79 MPH	A / C	BNSF	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Port Chicago to Stege	28	1	45 MPH	ABS	BNSF	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Port Chicago to Martinez	6	1	79 MPH	CTC	UPRR	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Martinez to Oakland	30	2	79 MPH	CTC	UPRR	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Lathrop to Martinez	Lathrop to Tracy	10	1	25 MPH	TWC	UPRR	0.000	0.000	1.850	1.500	1.500	0.800	13.000	10.700
	Lathrop to Tracy	10							0.000	0.000			0.000	0.000
	Tracy to Antioch	30	1	25 MPH	None	None	0.000	0.000	4.500	2.400	4.500	2.400	0.000	0.000
	Antioch to Port Chicago	12	1	25 MPH	ABS	UPRR	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Antioch to Port Chicago	12							1.800	0.960	1.800	0.960		
	Port Chicago to Martinez	6	2	79 MPH	CTC	UPRR	0.000	0.000	0.900	0.480	0.900	0.480	0.900	0.480
	Port Chicago to Martinez	6					0.900	0.480	0.900	0.480	0.900	0.480		
Sacramento to Merced	Sacramento to Stockton - UP Sac	48	1	70 MPH	CTC	UPRR	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Corridor			Current Condition 2006				Study Alternatives							
	Sacramento to Stockton - UP Fresno	48	1+	79 MPH	CTC	UPRR	7.200	3.840	0.000	0.000	0.000	0.000	0.000	0.000
	Sacramento to Stockton - UP Fresno	48							8.880	7.200			62.400	51.360
	Sacramento (Polk) to Stockton	42	1	25 MPH	None	None					54.600	44.940	7.770	6.300
	Stockton to Merced - UP Fresno	66	1	60 MPH	CTC	UPRR	9.900	5.280	0.000	0.000	9.900	5.280	0.000	0.000
	Stockton to Merced - UP Fresno	66							12.210	9.900			85.800	70.620
	Stockton to Merced - BNSF	66	1+	79 MPH	CTC	BNSF	9.900	5.280	9.900	5.280	9.900	5.280	9.900	5.280
	Stockton to Merced - BNSF	66									85.800	70.620		
Tracy to Los Banos		57	1	25 MPH	TWC	UPRR	8.550	4.560	8.550	4.560			0.000	0.000
Niles Juntion to Stockton	UP Oakland Subdivision (ACE)	63	1	79 MPH	CTC	UPRR	9.450	5.040	11.655	9.450	9.450	5.040	0.000	0.000
	UP Oakland Subdivision (ACE)	63							0.000	0.000			81.900	67.410
	Niles Junction to Tracy (Altamont Pass)	42	1	10 MPH	None	None	6.300	3.360	6.300	3.360				
Oakland to San Jose	UP Coast Subdivision	34	1+	70 MPH	A / C	UPRR	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	UP Niles Subdivision	31	2	79 MPH	CTC	UPRR	4.650	2.480	0.000	0.000	4.650	2.480	4.650	2.480
	UP Niles Subdivision	15.5											2.325	1.240
	UP Oakland Subdivision	20	1	60 MPH	CTC	UPRR	0.000	0.000	3.700	3.000			3.000	1.600
	Warm Springs Sudivision	18	1	25 MPH	ABS	None	0.000	0.000	3.330	2.700			23.400	19.260
	UP San Jose Branch	19	1	10 MPH	None	None	0.000	0.000			2.850	1.520		
San Francisco to San Jose	Caltrain Corridor	47	2+	70 MPH	CTC	PCJPB	7.050	3.760	8.695	7.050	61.100	50.290	61.100	50.290
Redwood Juction to Newark	Old SP Dumbarton	11	1	10 MPH	None	PCJPB	1.650	0.880	2.035	1.650	1.650	0.880	14.300	11.770
San Jose to Salinas	San Jose to Gilroy	30	1+	79 MPH	CTC	UPRR	4.500	2.400	0.000	0.000	4.500	2.400	4.500	2.400
	San Jose to Gilroy	30							5.550	4.500	39.000	32.100		
	Gilroy to Salinas	38	1+	60 MPH	CTC	UPRR	5.700	3.040	7.030	5.700	5.700	3.040	5.700	3.040
Iron Horse Trail	Old SP San Ramon Branch	30	None	None	None	None	0.000	0.000					0.000	0.000
Santa Cruz to Watsonville		21	1	10 MPH	None	None	3.150	1.680	3.150	1.680	3.150	1.680	3.150	1.680
Castroville to Monterey		13	1	0	None	None	1.950	1.040	1.950	1.040	1.950	1.040	1.950	1.040
Carnadero to Hollister		13	1	10 MPH	None	None	1.950	1.040			1.950	1.040	1.950	1.040

Corridor			Current Condition 2006				Study Alternatives							
Old Sacramento Northern	West Sacramento to Riverview	4	1	10 MPH	None	None								
	Riverview to Dozier	17	0	0	None	None								
	Dozier to Montezuma	26	1	10 MPH	None	None								
	Montezuma to Chipps	3	0	0	None	None								
Totals	Value in $ Millions						105.300	56.160	148.325	103.490	351.190	263.350	410.195	319.990